

**COMMERCIAL APPLICATION OF  
THERMAL PROTECTION  
SYSTEM TECHNOLOGY**

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**INTRODUCTION**

This paper focuses on the thermal protection system process technology used in the manufacture of the External Tank for the Space Shuttle system and how that technology is applied by private business to create new products, new markets and new American jobs.

The term "technology transfer" means different things to different people and has become one of the buzz words of the 1980s and 1990s. In the context of this paper, "technology transfer" is defined as a means of transferring technologies developed by NASA's prime contractors to public and private sector industries.

**Background - Manned Space Systems and Technology Transfer**

Despite the tens of thousands of spinoff products and processes from NASA, the majority of small to mid-sized businesses in the United States do not understand the term or concept of technology transfer. In fact, you might say that technology transfer is one of the best kept secrets in America.

Prime contractors like Martin Marietta Manned Space Systems have always had the contractual requirement to report all new technology developments to the contracting agency. In October, 1989, Martin Marietta Manned Space Systems' contract was expanded to expedite the movement of technologies from the "technology closet" to the market place.

Through this new contract clause, Martin Marietta Manned Space Systems has set out to familiarize the public and private sectors with how easy it is to take advantage of Federally-developed technologies for commercial usages through the "NASA/Martin Marietta Manned Space Systems Technology Transfer Program". As a result of these efforts, four commercial applications of External Tank-developed technology have transpired since October 1989. Two of these applications will be discussed in this paper.

**Background - Federal Legislation**

Although "technology transfer" is one of America's best kept secrets, it shouldn't be, according to the legislation passed to support the effort. Technology transfer was one of the major considerations of the National Aeronautics and Space Administration when it was created. In Congress' first effort to show a commitment to technology transfer, the National Aeronautics and Space Act of 1958, as amended, provided a clear mandate for the NASA to have an active Technology Transfer Program. However, simply mandating a Technology Transfer Program fell short of getting American business interested in developing

NASA-derived technology. The lack of interest by business was due to the fact that newly developed technology was considered public domain.

Later attempts by Congress in 1980 to foster the commercialization of Federally-developed technology resulted in two laws being passed. For the first time, the Bayh-Dole Act allowed the government to grant exclusive commercial sector rights to Federally-developed technology to the contractor who developed the technology with federal funding. By allowing this technology to be exempt from the public domain, this law removed a major stumbling block for private industry investment.

The second law, the Stevenson-Wydler Act authorized Federal laboratory personnel to share government-funded technology with the private sector. Until this law was passed, other than NASA, Technology Transfer was not part of the Federal laboratories mission.

Still not seeing the kind of results it was looking for, the Congress enacted the Federal Technology Transfer Act of 1986 in response to the increasingly tough international economic competition facing the United States from Japan, the Pacific Rim nations and the industrialized nations of Europe. The Federal Technology Transfer Act along with President Reagan's multi-phased program for improving access to Federally-funded research contained in Executive Order 12591, charged Federal agencies with linking their Federally-developed technologies with the private sector.

NASA, with its long-standing history in the Technology Transfer arena and in the spirit of the Federal Technology Transfer Act, decided through the Marshall Space Flight Center (MSFC) to increase their technology transfer efforts by allowing its prime contractors to implement complementary programs. This pilot program being conducted by Martin Marietta Manned Space Systems is helping to expand the network for transferring NASA/contractor-developed technologies.

#### **Background - External Tank**

Martin Marietta Manned Space Systems, Michoud Assembly Facility, New Orleans, Louisiana manufactures the External Tank for the Space Shuttle system. The Space Shuttle system is comprised of four major elements: The airplane-like orbiter, its external propellant fuel tank, and twin solid rocket boosters. The Space Shuttle system's largest element, the External Tank, is the structural backbone of the vehicle. It provides liquid cryogenic propellants to the orbiter's three main engines and absorbs the 6.7 million pounds of thrust exerted by the solid rocket boosters and main engines during launch.

To manufacture an External Tank that is 154 feet long, nearly 28 feet in diameter and has a propellant capacity of 528,600 gallons (1.6 million pounds), numerous technologies must come into play.

To keep the liquid hydrogen and liquid oxygen in the External Tank prior to launch, at -423°F and -297°F respectively an excellent thermal protection system is required. A polyisocyanurate foam was chosen to perform the task. The External Tank is covered over most of its surface with a layer of the foam about 1 inch to 1 1/2 inches thick. In addition to insulating the cryogenic liquid contents of the tank from its exterior environment and keeping these propellants from boiling off or causing ice to form on the exterior of the tank, the foam insulation also protects the tank's aluminum skin from the extreme heat caused by aerodynamic heating during the ascent portion of the mission. The foams and application processes developed to allow the External Tank to survive the extreme conditions it encounters are now finding their way into the commercial sector, helping companies create or improve their products.

## **MARTIN MARIETTA MANNED SPACE SYSTEMS TECHNOLOGY TRANSFER PROGRAM**

Manned Space Systems' first experience with transferring space-developed technology was a project referred to as the "Childrens Lunchbox Meals". Eleven million children do not have access to proper lunch time meals at school. With that fact in mind, Dr. Blackwell founded SouthPointe Products in Birmingham, Alabama, to manufacture and market a unique food product. SouthPointe Products offers parents a healthy alternative for their children's diets with a product that is nutritious, convenient to prepare, and that can be heated at home and retain its warmth for several hours until the child is ready to have lunch. The meals will be packed in thermoformed, high barrier plastic single serve trays with non-foil, easy peelable lidding. Some meals will be packaged for the child to heat and eat immediately; others will be provided with an insulated "meal mitt" or "cocoon" so that they can be heated and stored in the child's lunch box for several hours prior to eating. Dr. Blackwell's problem was to develop a "meal mitt" or "cocoon" that would insulate the meal and maintain the temperature of the meal at approximately 110°F for four to five hours. She contacted the Marshall Space Flight Center with her technical problem in the field of thermal materials. This problem was forwarded to Martin Marietta Manned Space Systems since one of the major areas of our expertise is the field of thermal protection technology developed for the External Tank.

After Manned Space Systems engineers established that this problem could be solved using thermal protection materials and processes developed under the External Tank contract, an applications engineering project was initiated with SouthPointe Products. This project included (1) analysis and testing to prove the concept of using foam as the "cocoon" material, (2) vendor surveys to determine production feasibility/costs to manufacture Manned Space Systems' concept, and (3) development of prototype "cocoons" for SouthPointe Products.

The results of this project demonstrated that it was feasible to use urethane foams as insulation for this microwaveable meal. A 0.5 inch thick foam shell would be required to keep the meal warm (~110°F) for four to five hours (Ref. Figures 1 & 2). Dr. Blackwell's production cost will vary with the vendor making the shells and the foam being used.

At the completion of this applications engineering project all patent and intellectual rights were assigned to SouthPointe Products. NASA, however, by law always retains a non-exclusive, non-transferrable, irrevocable, paid-up license for any technology developed with government funding.

Currently, SouthPointe Products has a patent pending on the foam "cocoon" concept and is working with an Atlanta firm to produce and market Dr. Blackwell's quality lunchbox meals for kids, coined "Power Packs".

Another example of an applications engineering project that will lead to commercial application of thermal protection system technology is the thermal curtain project. United Service Equipment Company (USECO) of Murfreesboro, Tennessee manufacture and markets the durable UNITRAY® cart, the original and completely proven single-tray heated and refrigerated food cart. Each of the double tray compartments is divided into two sections, one heated and the other refrigerated. It is this unique system that permits the tray to be assembled as a completed meal in the central kitchen, under the supervision of the dietitian, and delivered directly to the patient. Both hot and cold foods, side by side on the same tray, arrive at bedside appetizingly fresh because the UNITRAY® is designed not only to transport the trays but also to maintain food temperatures.

USECO has manufactured the UNITRAY® cart since the mid-1960s. From that time through the mid-1970s it was a very big seller for them. In the late 1970s to the early 1980s, the UNITRAY® started to lose its market appeal. Other manufacturers had introduced several products similar to the UNITRAY®, but with superior insulating properties. This new marketplace competition led USECO to contact NASA through the State of Tennessee Department of Economic and Community Development in search of technologies that could replace the neoprene divider system they were using at that time.

Because of Martin Marietta Manned Space Systems' expertise in thermal protection systems, the George C. Marshall Space Flight Center asked that we review this problem.

A team of engineers representing materials engineering, thermal engineering, mechanical design engineering and advanced manufacturing technology engineering were put together to review the USECO UNITRAY® food cart current thermal barrier. Several concepts were developed and presented to USECO for their opinion and consideration. Upon USECO agreeing with a proposed concept to utilize thermal protection materials to solve their problem, an applications engineering project was begun with USECO.

The objective of this program was to develop a foam-based thermal curtain system concept (Ref. Figures 3 & 4) which provides an insulating barrier between hot and cold chambers capable to maintaining fixed temperature conditions at 80-100 percent relative humidity for a given period of time. Test conditions would include maintaining contrasting temperatures of 250-275°F and 34-40°F for 2 hours.

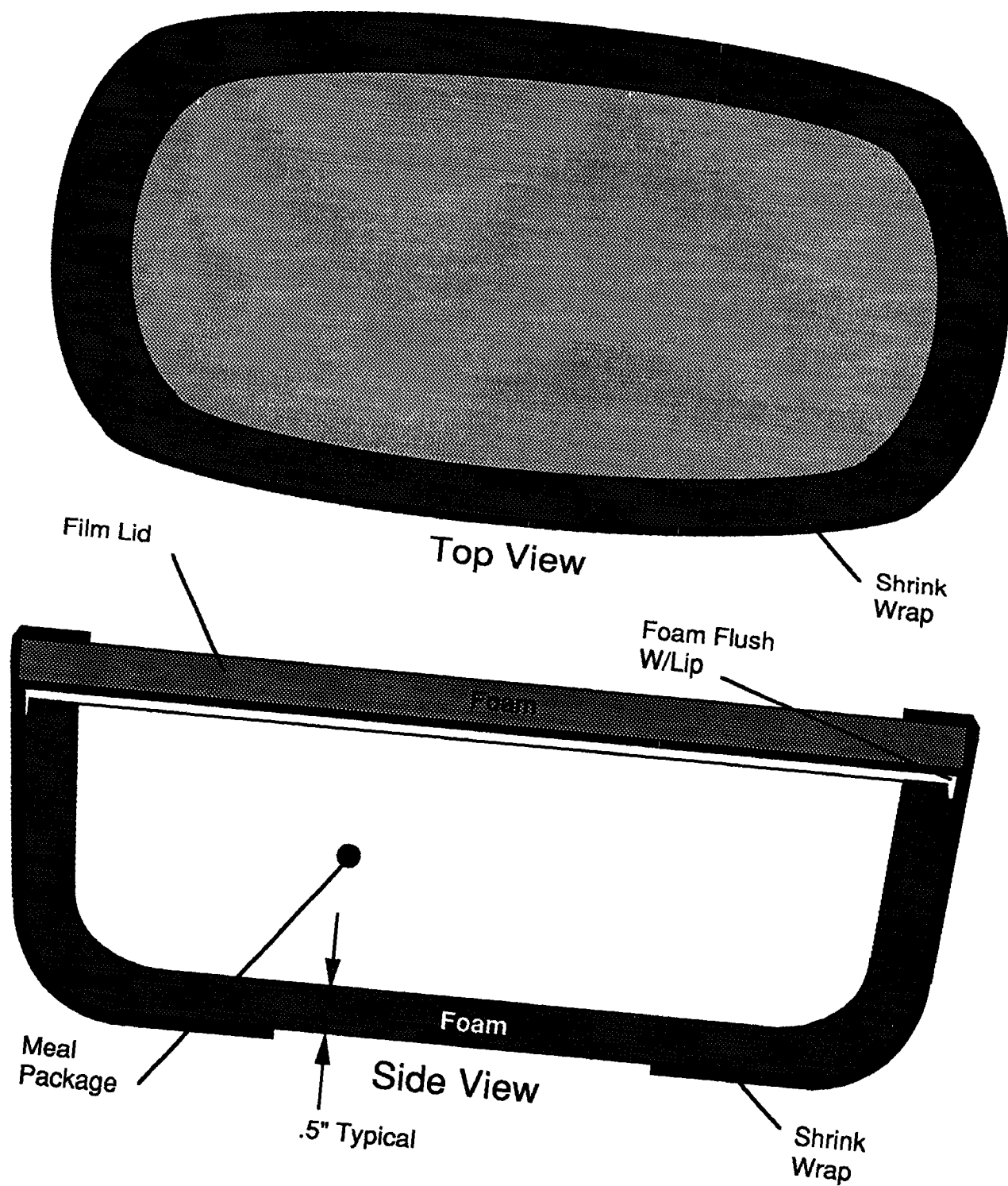
The approach to conducting this project include: (1) The development of engineering drawings, (2) development of prototype molds and prototype parts, (3) in-house analysis and testing to prove the concept, and (4) mocking up the UNITRAY® cart with prototype parts and performing an environmental acceptance test as the final proof of concept.

USECO plans on reintroducing the UNITRAY® cart with the new foam barrier systems in 1992. As with the lunchbox project, Martin Marietta Manned Space Systems disclosed all reportable items to NASA pursuant to NASA FAR supplement clause 18-52.227-70, "New Technology" and at the same time requesting that NASA waive its rights to the "UNITRAY® Delivery Cart Thermal Curtain." Upon the issuance of this waiver, Martin Marietta Manned Space Systems will assign its rights to the United Service Equipment Company who will file patent applications on the thermal barrier.

### CONCLUSION

With results like these, it is easy to understand why "Technology Transfer" can and does work for the American people. The projects cited in this paper deal with thermal protection systems technology. However, these are just two of the several applications engineering projects Martin Marietta Manned Space Systems has been involved in since October 1989. Manned Space Systems also has expertise in the fields of advanced manufacturing, advanced inspection systems, and advanced materials.

The NASA/Martin Marietta Manned Space Systems Technology Transfer Program is a positive way to take advantage of the technology being developed with your tax dollars, and a way of putting the United States back in the driver's seat as the world leader in manufacturing.

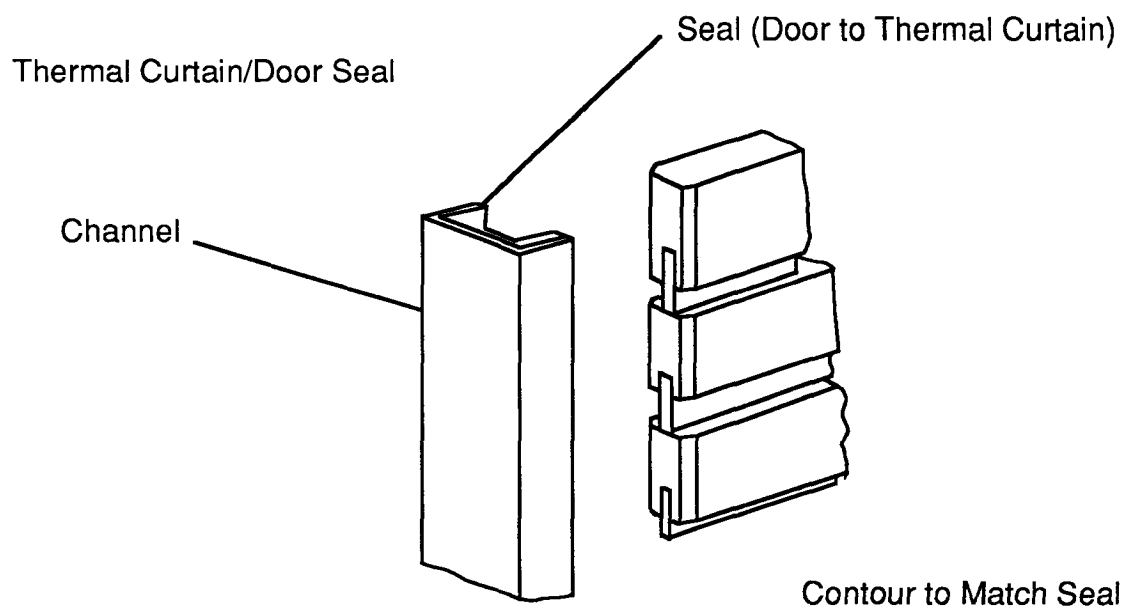
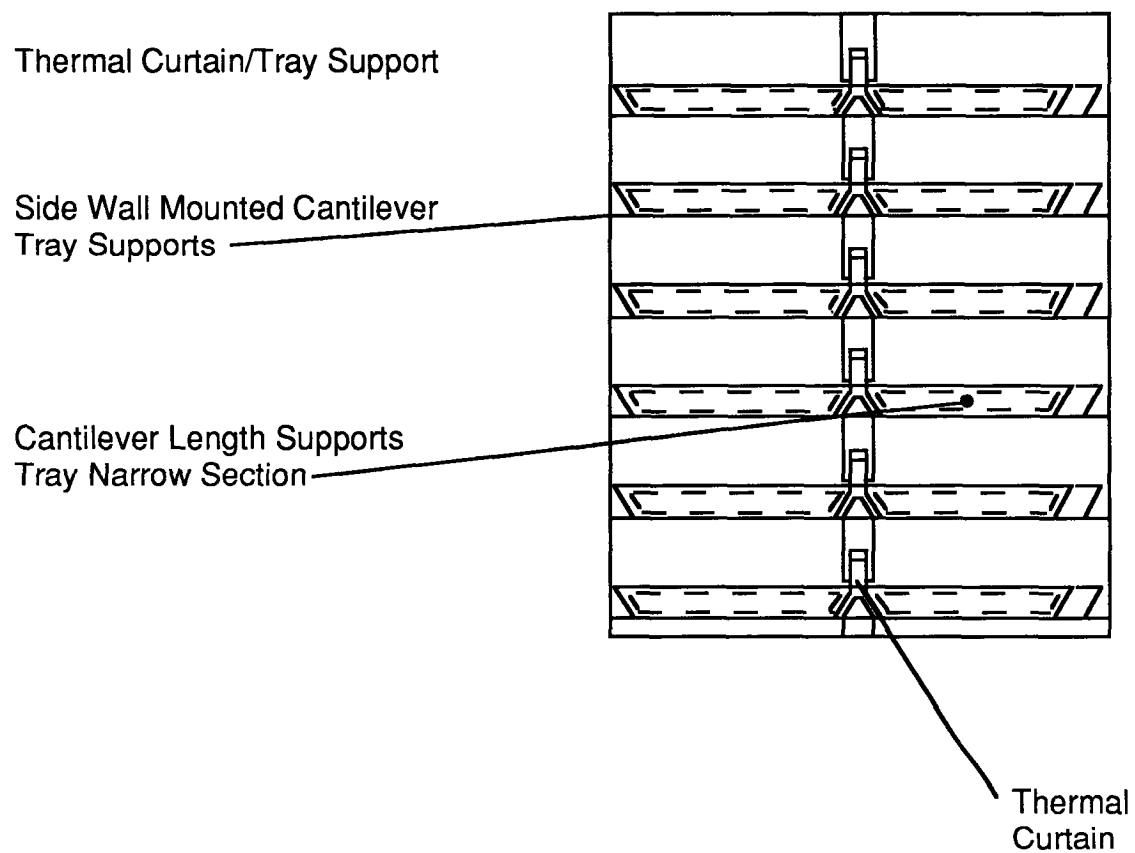


**Fig. 1 SouthPointe Products' Children Lunchbox**



**Fig. 2 Children's Lunchbox Being Heated in Microwave**

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**Fig. 3 Thermal Curtain**



**Fig. 4 Thermal Curtain New Foam Concept and Current Divider System**

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